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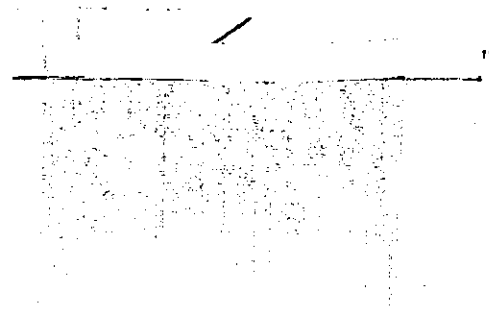

MAN-MADE LAKES AND WATERWAYS
WITHIN RESIDENTIAL DEVELOPMENTS

A THESIS

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the Faculty of the Graduate Division

by

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In Partial Fulfillment

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MAN-MADE LAKES AND WATERWAYS

WITHIN RESIDENTIAL DEVELOPMENTS

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ABSTRACT

In many communities throughout the country, artificial bodies of water are being created as integral parts of residential developments. These water-bodies, which may be classified as man-made lakes or waterways, are being developed for several reasons. They may function as part of a community water-control program and they may permit developers to reclaim certain land areas. Water is also desired by many persons for its recreational uses and for its esthetic qualities. Undesirable conditions, however, may result from the impoundment of water in residential areas. The objectives of this study are to investigate associated problems, to review controls and regulations, and to recommend policies for the creation and utilization of such bodies of water.

Although lakes and waterways serve useful purposes, adequate consideration must be given to the effect these bodies of water may have on the health, safety, convenience and general welfare of persons in the community. For this reason, some local governments regulate the impoundment of waters within their jurisdiction. One method of accomplishing this is to include provisions for the regulation of man-made bodies of water in local legislation controlling the subdivision and development of land. Platting regulations may specify standards for the design and development of such bodies of water and may require review of proposed lakes and waterways prior to development by officials of local government.

In order to reserve those areas required by communities for future

lakes and waterways, local governments may adopt official maps delineating necessary sites. Designation of such sites enables adjacent land to be subdivided and developed in conformity with these proposed public improvements. Permits are also being used by various agencies of government to control the creation of artificial bodies of water. Proper enforcement of permit requirements can prevent development of lakes and waterways that do not comply with standards established by the community.

The manner in which lakes and waterways are used and maintained may become a matter for public regulation. In some communities recreational activities, such as swimming and boating, have been restricted to those areas specified by the governing body as suitable for such use. Local governments may levy special assessments against property located near lakes and waterways in order to provide necessary maintenance of such bodies of water.

In addition to these public forms of regulation, private controls, such as protective covenants and property owners organizations, are also available to help maintain good standards in the design, development, use and maintenance of water areas. Proper use of these aids by developers and by local governments can help to insure that man-made lakes and waterways will be an asset to the development as well as to the community.

INTRODUCTION

Artificial bodies of water are sometimes created as integral parts of residential developments. The objectives of this study are to investigate problems associated with this type of development, to review controls and regulations, and to recommend policies for the creation and utilization of such bodies of water.

What are man-made lakes and waterways?--Artificial lakes differ from waterways in the same manner that natural lakes are distinguished from natural watercourses, as cited in the following discussion (1):

> ...it is encouraging to discover that the lawyer and the hydrologist are essentially in accord on the basic physical characteristics that distinguish a natural lake or pond from a watercourse. While lakes and watercourses are both bodies of water occupying a bed or depression in the earth's surface, the courts have contrasted the watercourse to the lake or pond on the basis that the water in a watercourse has a current of continuous motion, whereas in a lake or pond the water is substantially at rest.... A lake is essentially a "closed" or self-contained system.... Water courses, on the other hand, especially the larger streams and rivers, are "open" systems; they derive their characteristics from their basic function as conveyors of surplus water from land to sea.... To a greater or lesser extent both the lawyer and the hydrologist have recognized that there is a fundamental difference between a watercourse and a lake or pond, and that this difference is manifested largely by variance in the water movement....

The ability of waterways to move water, therefore, distinguishes them from lakes, as indicated by the definitions below:

man-made lakes -- independent bodies of water, substantially at rest, that would not have formed under natural conditions;

man-made waterways -- channels of water that would not have formed under natural conditions, which convey surplus water to adjoining bodies of water.

How are they developed?--Bodies of water may be developed from natural flows and from confined waters, or entirely new bodies of water may be created where none existed before. Lakes and waterways have generally been created by the following methods:

impoundment of water on the surface of the land, by construction of a barrier to restrict a flow of water; or

impoundment of water within the surface of the earth, by excavation of a basin.

Why are they created?--Lakes and waterways are created for both functional and social reasons. In some instances, the physical characteristics of the land require improvements in order for the site to be suitable for residential use and the creation of man-made bodies of water on such land is often the most practical way of accomplishing this. Areas containing swamps and marshes are examples of this type of land. Satisfactory development of such areas requires adequate consideration of two features -- "land" and "water." The problem may be too much water, or at least water in the wrong place, and too little land. In such cases, water must be removed from areas where it is not wanted into places where it can be disposed of or utilized for some purpose; and the land must be elevated sufficiently above the level of the water. Excavation is often the logical solution to both problems -- the removal of earth to provide drainageways and storage areas for excess water also provides fill for elevating and grading the land.

In the past, sites having physical defects such as low, marshy areas or other drainage problems have usually been by-passed by developers due to their unwillingness or inability to utilize such land. Recent

improvements (2) in earthmoving techniques and equipment, however, have enabled developers to reclaim these areas. In some places these sites have become very desirable for residential use because they are closer-in than other available land, and because the nature of the required improvements provides the opportunity to develop special attractions such as waterfront homesites.

Not all such development, however, is due to reclamation. In areas where there is sufficient demand for waterfront property, the impoundment of water on a given site may be justified even though the result is to decrease the amount of land that can be used for residential purposes. Water is a tool of land development that can be effectively used to create an interesting environment in which to live. Skillful use of this element may complement the natural features of the area, introduce variety into the landscape, and provide open space within the development. Bodies of water often have a restful and relaxing effect upon people and may appeal to their senses. Visually, water may appear as a kaleidoscope which reflects the sun, moon and other sources of light. To the ears it may deliver pleasant sounds as the gentle lapping of waves or the rhythm of raindrops striking the surface. In addition to these amenities, water is desired for recreation, which usually includes swimming, fishing, boating and related water sports; and where climatic conditions permit, ice skating and other winter sports.

Where are developments located?--This type of development is not restricted to any region of the country. One such development in the mountains of California has been described as ". . . one of several all-weather communities springing up through the Western and Rocky Mountain States with

emphasis on recreation. It lies on the south end of the lake at an elevation of 6,200 feet in the Sierra Nevada Mountains. . . . There are 30 lagoons . . . every lot has access to water" (3).

On the piedmont plateau of Georgia, a new town (4) is under development on a 15,000 acre tract of wooded terrain. Homes, apartments and recreation facilities have been oriented to a man-made lake covering 250 acres of land within the development. Another site has been reserved for the creation of an additional lake. Along coastal areas of Florida, many of these developments have been built. One community (5) covering almost four square miles has been designed for a site that is usually covered by one or two feet of water. In order to utilize such land, the plan is for the water to be "gathered together in one place." This is to be accomplished by development of numerous keys or fingers of land, "two lots plus one road wide," separated by channels of water.

In the southernmost Ozark foothills, six lakes were formed within a 2,000 acre development (6) by obstructing tributaries of the Arkansas River. A number of lakeshore parks were provided by the developer in order that every resident might conveniently use these lakes. A swampy area in the hills of New York was converted into gardens and lakes as part of the improvements to a 27 square mile combination scientific research and residential development (7).

Summary.--Man-made lakes and waterways, which have been created in various residential developments throughout the country, may provide:

fill material for improving the land;

a collection area or drainageway for storm water; and

a source of amenity and site for recreation.

CHAPTER I

CONSIDERATIONS IN DEVELOPMENT

Although the impoundment of water may be both useful and desirable, the creation of bodies of water in residential developments may result in conditions which affect the health, safety, convenience and general welfare of residents and others. These conditions, which should be given careful considerations by the community, the developer and individual property owners, are discussed below.

Water Quality

The quality of water in man-made lakes and waterways largely determines its suitableness for swimming and similar forms of water-recreation. Natural sources of water have been classified into the following three groups (8):

meteorological -- water which is precipitated from the sky;

surface -- water which collects on the surface of the earth;

ground -- water which percolates below the surface of the ground.

Meteorological waters such as rain, snow and hail are usually free from contamination and harmful substances; however, water which comes in contact with the earth readily absorbs and transmits impurities to which it is exposed. These impurities not only detract from the natural qualities of water by adding color, odor and taste, but may endanger the health and well-being of man and other creatures.

Water is a known carrier of disease which may transmit to bathers and others intestinal disorders such as typhoid and paratyphoid fevers, dysentery, and gastrointestinal upsets; eye, ear, nose and throat infections; respiratory diseases; and skin diseases such as ringworm, scabies, impetigo and "swimmers itch" (9).

Pollution of Water

Disease-carrying organisms and other harmful substances may be discharged into natural waters or may be introduced into artificial bodies of water after impoundment. Factors which contribute to the pollution of water are:

failure to treat wastes; or

inadequate design, operation and maintenance of collection and treatment facilities.

The major source of contamination to surface and ground waters is wastes from human bodies (10). These substances, which may contain harmful bacteria and pathogenic organisms, usually enter water due to the direct discharge of untreated wastes into water courses or other bodies of surface water.

Streams are often used for such disposal because they carry off objectionable matter deposited in them and because they tend to purify wastes by a natural process. The validity of both of these reasons is subject to examination, however, as noxious and undesirable substances from one community may be transported to another, and the self-purifying ability of water is subject to much variation. Self-purification depends on physical, chemical and biological changes which take place within the water. These natural changes are influenced by such conditions as dilu-

tion, sedimentation, reduction, oxidation, and by other factors such as temperature, sunlight, turbulence and stream hydrography, as indicated by the following (11):

> The rapidity of self-purification depends on the kind of organic matter, the presence of available oxygen, the rate of reaeration, temperature, sedimentation, and the velocity of the current. Sluggish streams are more likely to purify themselves in a shorter distance than rapidly flowing, turbulent streams, whereas the latter are more likely to purify themselves in a shorter time, other conditions being equal. The growth of algae, other biological activity, and the effect of sunlight and sedimentation may be more potent factors than oxygen reabsorption in self-purification.

Other bodies of water including bays, oceans, rivers and canals, have also been used for the disposal of wastes. After a recent study of waterways in southeast Florida, however, the State Board of Health concluded: "These canals cannot be compared chemically, physically or biologically with streams and their ability to assimilate domestic and industrial wastes" (12).

Treatment facilities range from the individual system which serves a single household to large systems which can treat the wastes from entire communities. Varying degrees of treatment may be given by these systems. The septic tank and disposal field, an individual facility commonly used to treat household wastes, is located underground on the property it serves. The treated liquid discharged by the system (effluent) is absorbed by the earth. In order for this system to treat wastes suitably so that ground water will not be contaminated, it must be properly designed and installed on the basis of local conditions and must be adequately maintained.

Treatment of wastes from large numbers of dwellings, from stores and offices, and from industrial activities requires a sewerage system to

convey the wastes from their sources to the site of treatment. Leakage of sewage (the water-born wastes in a sewerage system) is also a source of contamination to ground-water supplies. Another problem closely associated with the contamination of water has been the lack of suitable treatment facilities for boats and other watercraft. However, a private organization which prepares model legislation to promote effective boating laws, has recently stated the following (13):

> There are now available inexpensive devices which can be attached to marine toilets which effectively prevent pollution. These make unnecessary the adoption of the harsh rule requiring the sealing of all boat toilets while in certain areas.

Other wastes in addition to human by-products also require treatment. Substances such as acids and alkalies, grease, oil, and synthetic detergents should be adequately treated before disposal in surface waters as such matter may be harmful to man and may destroy fish and plant life.

Determining Suitability of Water

Two methods are generally used to determine the suitability of water for bathing -- bacteriological tests and sanitary surveys (14).

Tests of water can be made to determine the presence of coliforms -- harmless bacteria. Coliform organisms, which originate in the intestinal tract of warm-blooded animals, are commonly found in sewage. Existence of these bacteria in water indicates that it probably contains sewage and may, therefore, be contaminated. Additional tests can be made to determine the density of coliforms, i.e., the number of such bacteria within a measured volume of water. Coliform density is used as a measure of the

sanitary quality of water. Agencies concerned with the use of various bodies of water for recreation have developed standards to indicate the suitability of water for bathing and swimming. The following classification has been used by the Tennessee Valley Authority for waters under its jurisdiction.

Table 1. Bacterial Limits for Natural Bathing Waters (15)

Water Classification	Coliform Density Per 100 Milliliters
Satisfactory for Bathing	0 - 50
Satisfactory with Reservations	51 - 500
Use Doubtful; Not Recommended	501 - 1,000
Do Not Use	Over 1,000

Sanitary surveys supply information concerning the source of sewage; dilution resulting from infiltration, surface water, or storm water; relative freshness of the sewage; and environmental factors which influence the distribution of discharged wastes, as tides, currents or variations in the flow of water courses. Analysis of such information by qualified personnel can help to determine the suitability of water for recreational use.

Salt Water Intrusion

Excavation of waterways in some areas may encourage brackish water to advance inland. As the result, fresh-water supplies may become unfit for human consumption, and topsoil might become unsuitable for supporting normal plant growth. Sources of salt include not only bodies of

saline water, such as an ocean, gulf or bay, but also the following (16):

connate sea-water trapped in the ground at the time land was formed;

residual sea water which filled porous layers of earth when land was flooded by the sea;

salts from municipal and industrial wastes;

salts which remain on agricultural land after the evaporation and transpiration of irrigation waters.

Although salt-pollution might occur from any of these sources, it is most likely to be a problem in coastal areas where large volumes of water are withdrawn from permeable formations in contact with sea water. Intrusion of saline water into ground-water supplies in such areas is the direct consequence of a lowered fresh-water table (17).

As long as the ground-water table (which conforms generally with the local topography of the land) remains higher than the adjacent sea level, salt water does not intrude. If, however, the fresh-water table is lowered below sea level, saline water may infiltrate. A lowered water table may result from excess drainage of surface waters, or from removal of large quantities of ground water without an adequate recharge of the area by rain or other fresh water. Factors which contribute to these two primary causes of salt water intrusion are:

improper design, location and operation of wells used to obtain ground water;

increased demand for water;

drainage of low lands in order to reclaim such areas;

construction of drainageways without water-control facilities to regulate the flow of water; and

variations in rainfall or inadequate fresh water reserves to replace water removed from the ground.

The example below is a case history of salt water intrusion (18).

During the period 1907-1939 numerous canals were dug in South Florida to drain glades and marshes for agricultural use. These canals, which were not equipped with any means of regulating the flow of water, overdrained the land and lowered the fresh-water table. They also permitted salt water from the coast to flow inland. The result was a progressive encroachment and intrusion of salt water. Agricultural soils were endangered and well fields of two municipalities had to be abandoned and new wells located at sites farther inland. Since 1945 various water-control programs* have checked the advance of the salt-front and pushed it back as illustrated in Figure 1.

Fluctuation of Water Levels

Water levels in lakes and waterways may periodically exceed desirable limits. Fluctuations of impounded water occur due to such natural phenomena as the rise and fall of tidal waters, an increase or decrease in precipitation, and variation in the level of the ground-water table. Although normal fluctuations do not usually require special consideration, abnormal changes of water level may have serious consequences.

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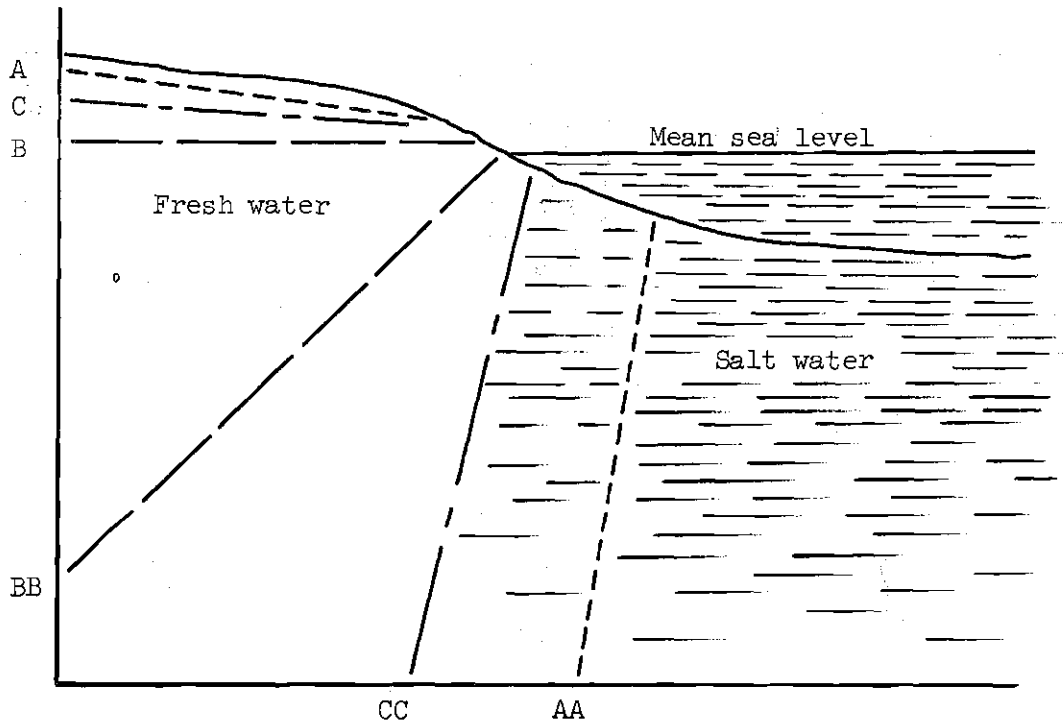
*Dade County Water Conservation District, established 1945 by the Board of County Commissioners, Dade County, Florida; Central and Southern Florida Flood Control District, a cooperative federal-state-local program established 1949 by the Florida Legislature and the Congress of the United States.



LINE A -- Original ground-water level
LINE AA -- Original barrier between salt water and fresh water

LINE B -- Overdrained ground-water level
LINE BB -- Distance salt water intruded

LINE C -- Recharged ground-water level
LINE CC -- Distance salt water pushed back

Figure 1. Intrusion of Salt Water Along Coast (19).

High Water

An excessive rise in the level of surface waters may result in flooding of adjacent land. Flooding of such land can cause property damage, produce health hazards and endanger life.

Tidal waters.--Abnormal rises in tidal waters are caused by such disturbances as storms, hurricanes and tsunami.* High velocity winds which accompany storms and hurricanes often result in excessively high tides in coastal areas. Seismic movements in the ocean's bottom may produce a rapid rise in the water level with highly destructive results along the shoreline. Creation of additional waterfront land by excavation of waterways along coastal lowlands may increase the amount of land exposed to flooding. Means of limiting the effects or preventing such an occurrence include:

development of land subject to inundation for uses which will not suffer severe damage from water or endanger life;

construction of water-control structures to regulate the level of water or to contain it within prescribed areas; and

elevation of the land above an anticipated high water mark.

Non-tidal waters.--Excessive quantities of surface water from rainfall or melting snow and ice may exceed the natural boundaries of watercourses and waterways. Properly designed and operated water control systems may alleviate such a situation by regulating the flow of water and by storing water until it can be safely released. Obstructions which restrict the flow of water may aggravate conditions however. Improper design of a barrier placed across a stream can result in the impounded water rising

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*A sea wave produced by submarine earth movement or volcanic eruption.

above a desirable high water level and flooding other areas.

The possibility of structural failure of facilities constructed to impound water should also be given adequate consideration as indicated in the following discussion (20).

> The building of large dams to create ponds or lakes is a highly technical engineering problem and should not be attempted by the amateur. The force of water, especially during spring freshets, is immense, and unless the dam is properly engineered it will be washed out causing great damage and possibly loss of life. In summer a stream may look innocent enough, and the temptation to dam it and create a pool or pond is great. In March this mild stream may become a raging torrent and it will tear out any obstruction that may have been placed in its path unless it has been properly engineered and constructed.

Low Water

Substantial lowering of a body of water may reduce its usefulness for swimming and boating, interfere with the propagation of fish, detract from its appearance and create undesirable odors, and produce conditions favorable to the breeding of mosquitoes.

Surface waters.--The ability of some basins to contain water depends on an impervious bottom or an impermeable layer in the underlying strata which prevents water from penetrating into the ground. Fracture of this seal by geological forces or by acts of man may cause loss of water by leakage and a lower water level. Complete drainage of lakes has resulted from such causes (21).

Ground waters.--In areas where the subsurface is porous and ground water may permeate through the aquafer, the level of a lake in an excavated basin generally corresponds with the ground-water table for that area. Lowering of the water table (from lack of rainfall or from removal of water from the ground) results in a similar decrease in the level of the

lake. Excavation of lake bottoms sufficiently below normal low water levels can help to maintain an adequate depth of water.

Land Erosion

The erosion process involves not only removal of matter from one place, but deposit of such matter in another place. Lakes and waterways may become vehicles for removal, as well as receptacles for deposit of soil.

Erosion

The wearing away of land may result from both natural and artificial causes. Natural forces include the actions of wind, rain, tides and currents. Man-made causes are those which increase the turbulence of water, such as the operation of boats; or the construction of any facility which intensifies the normal velocity or movements of water. The washing away of earth from adjacent property not only reduces the amount of such land, but may produce an unattractive rutting or "washboard" effect in the shoreline. Erosion can become so severe that it damages existing structures by undercutting their foundation.

Adequate knowledge of local soil characteristics and hydrography is necessary for the proper design of lakes and waterways. Creation of man-made bodies of water also results in the creation of artificial shores. Where land is composed of firm, stable material, the shoreline may usually be more vertical than in areas where the soil is loose. Various means of stabilizing the shore include planting of ground cover, application of cementing agents, and construction of retaining walls.

Siltation and Sedimentation

The problems of siltation and sedimentation may complement that of land erosion. Silt, which is fine matter suspended in the water, and sediment, heavier particles which settle to the bottom, are eroded soil particles in the water. Such matter may give the water a cloudy or muddy appearance, make it less desirable for swimming and unsuitable for some species of fish. Deposits of material on the bottom may build up into "mud flats" which are unsightly and often produce an unpleasant odor. These formations also restrict the flow of water, limit the circulation of boats, and reduce the storage capacity of the basin.

Natural Vegetation and Foreign Matter

The tendency of lakes and waterways to become areas for the collection of foreign matter and the propagation of plant life may limit their potential usefulness for recreation. These conditions may also result in an undesirable environment within residential areas.

Natural Vegetation

Surface water is the natural habitat for certain species of aquatic plants which have been classified as follows (22):

floaters -- normally free floating and move with the surface current -- e.g., hyacinths and algae;

submerged aquatics -- submerged plants that generally wave in the current as "mossy" streamers -- e.g., Coontail and Muskgrasses; and

emerged aquatics -- generally rooted in moist to flooded soil and spread from the banks of streams and ponds or emerge above the water surface from the bottom -- e.g., Para grass, Sawgrass, Alligator weed and Cattail.

Some species of plants are desired for their attractive and ornamental appearance. Their existence in lakes and waterways, however, can result in unfavorable conditions.

Objections to aquatic vegetation are related to both the density of such growth and to the uses of the water. Even a small amount of vegetation is usually undesirable in swimming areas because of its unpleasantness to those coming in contact with it. Continued growth of vegetation under favorable conditions can cover the surface or saturate the subsurface of a body of water with plant life. Such uncontrolled growth may become so dense that it prevents the operation of boats and causes the death of fish. This condition also restricts the flow of water and encourages stagnation. In addition, decomposition of vegetation in water may increase coloration and produce offensive odors.

Methods of controlling aquatic weeds include the following (23):

natural -- where water control facilities exist, fluctuation of water levels can be used to drown some vegetation and to strand other plants without the water necessary to sustain life;

manual -- includes the use of numerous hand or power-operated tools to cut, gather, and remove growth from the water;

mechanical -- the operation of mechanical equipment such as mowing machines from amphibious craft or land vehicles;

chemical -- use of organic herbicides or other chemicals to destroy plant cells on contact, to destroy root systems and sterilize soil, and to destroy from within after absorption by plants.

Chemical agents must be used with great care, however, as they are potentially dangerous to man, domestic animals and fish.

Foreign Matter

Rubbish, trash and scrap material such as paper, rags, wood, glass, metal and yard cuttings may be deposited in bodies of water by man or transported from other places by wind and water. Such foreign matter detracts from the appearance of the area, limits recreational use, and may have other detrimental effects. Obstructions such as large pieces of lumber and tree limbs are a menace to small boat operation and many smaller objects are dangerous to bathers and a nuisance to fishermen.

Accumulations of debris and vegetation also offer protection for snakes, rats, or other creatures common to the area. One pest that is encouraged to develop in such an environment is the mosquito. This little insect not only causes much discomfort to man, but has been a carrier of such diseases as malaria, yellow and dengue fever, and encephalitis (24). Mosquito breeding is closely related with the development of bodies of water as mosquito eggs are laid in water or in moist soil. Furthermore, these eggs hatch into larvae (immature mosquitoes) which live in water until they mature to adult stage. During this immature phase the unprotected larvae are subject to control by a natural enemy -- the minnow. Foreign matter and vegetation in the water which prevent fish from reaching and devouring larvae, however, provide protection and promote the breeding of mosquitoes.

Circulation

Lakes and waterways may supplement man's mobility by providing areas for the operation of pleasure boats and watercraft. These same bodies of water, however, may restrict land transportation by interrupt-

ing traffic patterns and interfering with the movement of pedestrians and motor vehicles.

Circulation on the water is restricted by the construction of structures which obstruct the free, safe movement of boats. Included in this category are roadways and utility crossings, structures for water control, and facilities for recreation. It may be necessary to cross bodies of water to allow for land circulation and the extension of utilities. Water control facilities such as dams or salinity barriers may also be required. Failure to provide suitable means of passage for pleasure boats and adequate height, width, and depth clearances, however, may seriously limit the use of such water for recreation.

A report prepared for Metropolitan Dade County, Florida, on the recreational potential of drainage canals indicated that the area would benefit by pleasure boat navigation and recommended that the government should (25):

. . . require that existing and future dams in canals provide facilities for navigation;

require that navigational requirements be considered when new bridge facilities are constructed.

Recreational facilities built out from the shore such as piers and docks may also obstruct navigation if extended too far into the water.

Conflicts between land and water circulation are closely associated with the design of artificial bodies of water. The shape of natural bodies of water and those created by the obstruction of a stream is determined largely by the topography of the site. Lakes and waterways

created by excavation, however, may be designed on the basis of other criteria. One factor which may influence their form is the amount of earth to be moved. When large amounts of material are required, excavation usually progresses across broad areas of land resulting in the creation of open bodies of water. Another technique is to design the development in such a manner that fill removed from excavation areas can be deposited directly on building sites without hauling such material by vehicle. When this method is used, relatively narrow channels of water are created.

Narrow channels may restrict circulation of the water and encourage the accumulation of vegetation and foreign matter. Where such channels are long and open only at one end, the water may become stagnant. The restrictive nature of channels limits their desirability for boating. Activities such as sailing and skiing are safer and more enjoyable in open waters. The operation of power boats in confined areas also causes severe turbulence of the water which may result in serious erosion of the land. These channels often serve as convenient sites for mooring boats and are well suited for this purpose if located near larger bodies of water that are suitable for boating. Docks and other facilities along the shoreline and boats moored in the water, however, reduce the effective width of such channels and further restrict circulation.

Development of numerous channels without sufficient crossings may inhibit the movements of pedestrians and vehicles. Excessive crossings, however, can be impractical as bridges and other structures across water are expensive to construct and to maintain. They might also restrict the operation of watercraft. Maintaining suitable distances between

crossings, therefore, may improve internal circulation within developments.

Water Safety

The creation of new lakes and waterways provides additional opportunities for persons to participate in various water sports and activities, particularly in areas where there are few natural bodies of water. Increased use of water for recreation, however, is usually accompanied by an increase in the number of water accidents. During two recent holiday weekends, two states had more deaths on the water than on highways (26).

Persons whose safety must be considered in the development of lakes and waterways may be grouped as follows -- those who actively use the water for recreation; and others who unwillingly enter the water as the result of some mishap. The latter category includes children, who are often attracted to water, and others such as the elderly or non-swimmers who are subject to accidental drowning by falling into the water. Incidents involving vehicles are additionally hazardous when they occur near water. Passengers may drown as the result of being trapped in vehicles which leave the roadway and enter bodies of water. The relationship between roadways and water, and the necessity for fences, guard rails or other barriers should therefore receive adequate consideration in the design of the development.

Conflicts often arise between persons using water areas for swimming, fishing or boating. Serious accidents, however, are usually related to the operation of power boats and result from such causes as collision of boats and water skiiers with one another, and with structures,

objects or persons in the water. Separation of activities, as well as regulation of power boats operating in such areas, should also be considered.

Another problem associated with the development of artificial bodies of water is abrupt changes in the bottom that may result from excavation. The existence of holes or places where the bottom drops off sharply from shallow water is particularly dangerous to non-swimmers who may step into water over their heads and drown.

Access for Maintenance

Man-made lakes and waterways require various kinds of maintenance. Where the necessity exists for improving the shore and the bottom, repairing structures and recreational facilities, or removing vegetation and foreign matter, adequate access must be available in order for such maintenance to be accomplished. The specific nature of the repairs or improvements may require either a way into the water or along the shore. Failure to provide such a way can cause a hardship to property owners. The moving of vehicles or other equipment across property used for residential purposes can result in damage to trees and shrubs, lawns and patios, outdoor lighting and water-sprinkler systems. It is important, therefore, that during the design stage of the development, consideration be given to the requirements for future maintenance in order that suitable access can be provided. Public and private property may both serve this purpose.

Access can be provided by public rights-of-way. Location of a public way along the shore, however, separates building sites from the water and reduces the amount of private waterfront property within the

development. When public rights-of-way are not utilized, easements may provide for the passage of maintenance equipment and personnel across private property. Easements of this nature can be created to give rights of ingress and egress to specified persons for a specific purpose -- as the performance of maintenance. These agreements, which may be created by deed (or other indenture) and by contract, should specify the following (27):

a description of the premises covered by the easement;

the nature of the easement and whom it benefits; and

provisions affecting the use and maintenance of land included in the easement.

Summary

The creation of lakes and waterways within residential areas is closely associated with the health, safety, convenience and general welfare of man.

Users of water for swimming and bathing can be exposed to infections or other communicable diseases. Persons can suffer injury and discomfort from chemicals, wastes and foreign objects in the water. Accumulations of dead fish and vegetation can produce obnoxious odors and promote the breeding of insects and other undesirable creatures. Waterways that connect with bodies of salt water can permit saline water to flow inland and permeate into the ground. As the result, fresh water supplies can become unfit for human consumption or for domestic and agricultural use.

Water from lakes and waterways can flood adjacent land -- endangering life, producing health hazards, and damaging property. Soil can be

eroded by water. Removal of soil from land and deposit of such matter in bodies of water can detract from the usefulness and attractiveness of both areas. Lakes and waterways influence the character of the development and can create conflicts between circulation on land and on water. Numerous channels might require excessive roadway and utility crossings. Open bodies of water might be barriers that restrict efficient movement on land. Water in the vicinity of roadways can be an extra hazard to the motorist. Aquatic weeds and foreign matter can choke narrow channels of water and promote stagnation.

Many of these problems can be resolved by proper design and construction. Others require maintenance of one form or another after bodies of water have been created. Methods of promoting sound initial development and maintaining continued high standards are discussed in the following chapter.

CHAPTER II

CONTROLS AND REGULATIONS

In order to promote and maintain good residential areas, it may be desirable to consider the creation of artificial bodies of water along with the subdivision of land. Control of the design and development of lakes and waterways, as well as their use and maintenance, may become necessary. Both private and public controls are available for this purpose. Private regulation is exercised through private ownership which embraces the rights of possession, control, enjoyment and disposition (28). Possession and control enable enjoyment of the benefits derived from the use of land and include the right to alienate or transfer these rights to others, subject to limitations and restrictions imposed by the state or created by contract.

Authority for public control is based on the following powers of government (29):

police power -- enables establishment of broad regulations which protect the life and health of persons; secure their existence and comfort, safeguard them in their enjoyment of private and social life and in the beneficial use of their property;

licensing power -- implements registration, inspection, and regulation of businesses, activities, things and persons in the public interest;

penal power -- authorizes imposition of punishment and penalties upon persons for acts in violation of the law;

financial power -- allows collection and expenditure of funds in order to administer governmental responsibilities;

power of eminent domain -- permits acquisition of land or easements for public purposes, provided just compensation is paid.

Although these powers may be classified separately, as above, they frequently overlap and are often used jointly. Such powers are inherent in states and may be granted to cities and counties. This is usually accomplished by enactment of state legislation known as enabling acts. These acts specify the action that may be taken by local governments as well as the requirements that must be met. Powers granted to local governments may be utilized by enactment of suitable local legislation within the framework of state acts. This legislation usually indicates the procedure to be used in obtaining the desired results.

Design and Development

Public regulation of the design and development of lakes and waterways is being accomplished primarily through the use of plats, official maps, and permits.

Plats

One of the fundamental steps in efficient land development is preparation of a plat -- essentially a map which indicates existing man-made and natural features in addition to proposed changes. Legislation enacted by communities may stipulate that plats shall be officially recorded with the local government whenever tracts of land are subdivided or developed. As a prerequisite to being recorded, however, plats are reviewed to insure that they comply with provisions contained in the legislation. Requirements of this nature have been enacted under

various titles, such as land subdivision regulations, platting regulations and subdivision standards.

Plat review.--An informal meeting between developers and reviewing officials prior to preparation of a plat is recommended (30). The purpose of this meeting is to provide an opportunity for the exchange of information. Developers are encouraged to present sketches of their proposals and are informed of all local requirements or standards relating to the creation of lakes and waterways. After the initial meeting, the developer should have sufficient knowledge of local requirements to prepare the required plat and submit it for review.

Plats of proposed developments are reviewed to insure that they meet standards established by the local government. Standards for communities are usually recommended by their Planning Commissions. If the plat does not comply with such requirements, it is returned to the developer for correction and re-submission. When the plat complies with all requirements, it is approved for recording. This plat-review procedure is used by many municipal and county governments to guide the subdivision of land so that it will complement existing development. The Federal Housing Administration uses substantially the same procedure in connection with the approval of mortgage insurance for developments.

Design standards.--Although standards are commonly specified for the design of roadways, blocks, and lots, few standards have been adopted which relate to the creation of artificial bodies of water or the development of adjacent land. The following requirements, enacted by ordinance (31) of the City of St. Petersburg, Florida, are from the section entitled Waterway Developments.

1. Each waterway subdivision shall have indicated on the plat any covenants or restrictions as to:

   a. Boat houses

   b. Docks

   c. Development of beaches.

2. Width of waterways. . . shall be 100 ft. absolute minimum width, measured from front of seawall to front of seawall, plus that width necessary under the plat covenants for boat houses, docks, and beaches.

3. Where a plat does not incorporate covenants, either excluding or setting limits on boat houses, docks and beaches, the minimum width for waterways shall be 200 ft.

4. Where a finger projection of land is proposed that exceeds 1,000 ft. in length, minimum width of waterways shall be 200 ft., rather than 100 ft.

The City of Coral Gables, Florida, stipulates that bulkheads may be required on waterfront property (32) ". . . The minimum elevation of such bulkheads shall be plus 6 feet M.L.W. U.S.E.D.* Bay Datum, and the type and design shall be subject to approval of the Public Works Director." Dade County, Florida, specifies standards for the provision of maintenance access in the following manner (33).

> Whenever any drainageway, stream, or surface drainage course is located or planned in any area that is being subdivided, the subdivider shall dedicate such stream or drainage course

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*Mean Low Water United States Engineering Division.

and an adequate right-of-way necessary for maintenance, future expansion and other purposes along each side of such stream or drainage course as is determined by uniform standards prescribed by the manual of public works construction.

Official Maps

Some material can be presented better by graphics than by other methods. For this reason maps are used by various authorities to delineate some controls and regulations. When the subject matter is technical, however, maps should be carefully prepared by persons with adequate knowledge of the subject. Adoption of maps by governmental bodies gives them "official" status and makes them part of the public records. This is usually accomplished by enactment of legislation which specifies the purpose or intent of the map, measures for enforcement, and penalties for violation. Maps may be made a part of legislation by attaching reproductions, or by suitably identifying originals in the text. State legislation which authorizes local governments to perform this function is sometimes known as an Official Map Act. The following examples of official maps are related to the development of lakes and waterways.

Salt barrier line.--In order to restrict the inland advance of salt water into Dade County, Florida, the Board of County Commissioners enacted an ordinance (34) fixing a salt barrier line which ". . . shall constitute the westerly limit beyond which no new uncontrolled canals, channels, or continuous excavations from any salt contaminated areas easterly thereof

shall be excavated or constructed. . . ." The location of the line was indicated on an official map. Provisions for enforcement of the legislation included the following:

> No permit, license or authorization to excavate, create or construct any uncontrolled canal, channel, or continuous excavation from any salt contaminated area easterly of said salt barrier line shall be granted or issued, and no subdivision plat shall be approved or filed for record that provides or contemplates any improvements which would violate, breach or in anywise impair or constitute a waiver of the . . . Line.

The ordinance, which was enacted as an exercise of the police power vested in the County, stated that such regulation was ". . . necessary and essential for the preservation of fresh water resources and for the protection of the public health, safety and welfare. . . ." It was not the intent to prevent the creation of new waterways, but to require future waterways to have structures or dams located at the barrier line which would prevent the encroachment of salt water.

Water control plan.--Adequate drainage of much of the land in Florida depends on a network of primary and secondary waterways which convey excess storm water from inland areas to coastal waters. After considerable engineering study, Dade County adopted an official map by resolution (35) which delineated the location of a proposed system of waterways within the county. The intent of the legislation, which officially recognized the county's plan for water control, was to reserve rights-of-way necessary for drainage. Owners were prohibited from building in those

areas to prevent increased acquisition costs. It was the opinion of local officials that much of this land would be donated to the county in recognition of the benefits of improved drainage which would accrue to property owners. Adoption of the official map also had other advantages. Portions of waterways were excavated by developers at no cost to the county in return for the fill material. The subdivision and development of land and the design of other drainage facilities were coordinated with the proposed waterway system.

Flood criteria.--Much of the low, flat land in Florida is subject to flooding. In order to improve drainage and reduce the threat of floods, Dade County established elevation standards for the development of land within its jurisdiction. These standards specify minimum elevations to which building sites and roadway-beds are required to be filled prior to construction upon the land. A base map of the county was prepared with contour lines representing the natural topography of the land. An additional set of contours was superimposed on the map to indicate the minimum elevation required for land development. The difference between the two sets of contours is the height of fill required to raise the land to the minimum elevation.

The official flood criteria map was adopted by a resolution (36) which states that the map ". . . is not intended to be a representation to any person that . . . (construction) . . . on land having minimum elevations as shown on said map will be safe from flood waters at all times, but it is intended to reflect the opinion of . . . (various agencies) . . . that the elevations shown are the minimum that should be permitted . . . ." Strict application of the standards are not desirable

in all cases as indicated in the following discussion (37).

> When fill is required in undeveloped areas surrounded by lowlands already developed, reasonable transitions must be provided between lot and street levels of two adjoining areas, and special drainage facilities must be installed as necessary, by the developer, to prevent increased flood and ponding damage to areas already developed.

These criteria do not regulate the creation of lakes and waterways, but control the development of land. Use of such standards, however, may limit the flooding of land adjacent to bodies of water. In areas where it is common practice to obtain fill from on-site excavations, regulations of this nature may actually encourage the development of lakes and waterways.

Permits

Governing bodies effectively use permits to regulate many activities. Physical changes -- as excavation, filling, grading, inundation and drainage of land; or construction and removal of structures upon the land -- are commonly regulated by permits. This method of control is used at all levels of government.

Federal permits--Navigable bodies of water can be adversely affected by man-made waterways. For this reason federal laws (38) require that application must be made for authority to excavate into navigable waters of the United States. Connection of waterways with navigable waters is prohibited unless recommended by the Chief of Engineers and authorized by the Secretary of the Army, who are responsible for the administration of laws for the protection of navigation. Authorization, which is ordi-

narily granted in the form of a permit, is limited as follows (39).

> The permit does not give any property rights either in real estate or material, or any exclusive privileges; it does not authorize any injury to private property or invasion of private rights, nor does it obviate the necessity of obtaining State assent to the work authorized. It merely expresses the assent of the Federal Government so far as concerns the public rights of navigation.

State permits.--The Central and Southern Florida Flood Control District has jurisdiction over natural rivers and streams, and man-made canals, levees, and dikes within the boundaries of the District -- primarily in the interest of flood and water control. In order to carry-out its program, the District exercises control over any connections made to these natural or artificial bodies of water, as well as any structures in or across such works. The connection of additional waterways to this system is prohibited by State Law unless approved by the District. Permits are used by the Governing Board of the District to grant approval. Such a permit is ". . . simply an acknowledgment that the specific use of Public Land as requested by the Applicant, is proper and conforms to the requirements and standards of the Flood Control Law" (40). Permits are not issued for any construction or excavation that would interfere with or impose hardships upon the District's operation and maintenance.

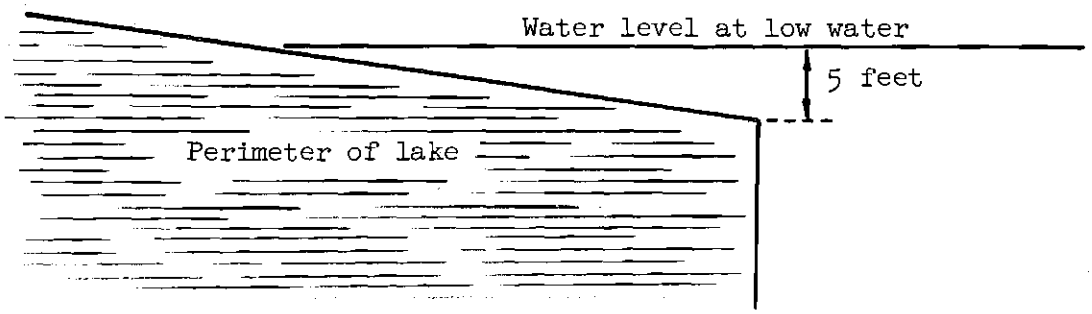
Other State agencies also regulate the development of lakes and waterways. For example, the Sanitary Code of Florida (41) contains the following provision.

> Any person, firm, corporation, county, or municipality

> desiring to impound water, or who proposes to raise the level of a previously existing pond by the elevation of point of overflow of a dam, shall, prior to the initiation of any construction activities, make application to the State Board of Health for, and obtain from it, preliminary permit for the impounding of such water.

Local permits.--Creation of lakes and waterways in Dade County, Florida, is controlled in part by requiring permits for excavation. Permits for approved excavations are often issued subject to specified conditions. One common requirement is that the perimeter of lakes (the shore and lake bottom adjacent to the shoreline) be graded in such a manner that a gentle slope is provided into the water until a depth of five feet is reached. This provision is illustrated in Figure 2. The objective of this requirement is to limit drownings which might result from inconsistencies in the bottom. The five-foot minimum was established on the assumption that non-swimmers will not advance into water of this depth. Waterways are not required to have sloped shorelines. Instead, a minimum overall depth is usually specified to limit the growth of vegetation on the bottom. Where necessary, excavation permits are issued subject to the condition that fences be provided in order to prevent persons from entering the water.

Commercial excavations for rock and other materials are also regulated by special provisions. In addition to the slope requirement discussed above, excavation areas are required to be set back a specified distance from property lines and from public rights-of-way. As the result, excavated areas, which usually become artificial lakes, are



REQUIREMENT: One foot vertical for each seven feet horizontal into a minimum depth of five feet of water at low water elevation.

Figure 2. Slope Ratio for Perimeter of Lake.

separated from roadways and adjacent property by a strip of natural land. These land areas help to prevent wayward vehicles from entering such bodies of water and provide sites for future waterfront development.

Construction of structures such as dams, piers, docks, boating and recreation facilities in man-made lakes and waterways may also be regulated by permit when a public purpose justifies such control.

Protective Covenants

Contracts made between private parties, which constitute an agreement as to the way land may be used in order to protect and preserve the physical, social and economic integrity of areas, are known as protective covenants (42). Terms of such agreements may be recorded with the deed and the plat, or by use of another document. A procedure that has been suggested is to include only basic restrictions as part of the recorded plat. Special provisions which affect only specific sites should be added to the deeds of such property. Comprehensive covenants for the entire area being developed should be applied simultaneously by a separate instrument. One development corporation enacted the following provisions in the form of a resolution (43).

> No boat house or dock building shall be erected on or adjoining any of the lots in . . . subdivisions, but a dock extending such a distance from the line of the high water mark of the waterfront lots as may be approved by . . . (the corporation) . . . may be permitted; and no boat landing, dock or pier shall be constructed until the plans and specifications thereof shall have been approved in writing by . . . (the corporation). No

> boat canal or other waterway shall be dug or excavated into any of the waterfront lots. . . . No lot or parcel shall be increased in size by filling in the waters on which it abuts. No sea wall shall be erected or constructed in this subdivision unless and until its location, design, materials, structure, strength, etc., shall have been approved in writing by . . . (the corporation).

Public controls are designed to establish minimum standards primarily in the interest of health, safety and welfare. Covenants may also serve the same purpose where public controls are inadequate. Protective covenants, however, may include a broader scope and may establish higher standards than can be justified under public regulations. For example, construction along the shoreline of lakes and waterways by various property owners may result in substandard improvements which detract from the entire neighborhood. Seawalls may be built on some lots and not on others, resulting in an unfinished appearance. Different materials and various architectural styles may be used in construction. Floats, docks, and other structures may be poorly fabricated from scrap material and allowed to deteriorate. Items of this nature, which are normally not matters for public regulation, may be controlled by covenants. Although protective covenants are contractual obligations, one of their weaknesses has been enforcement of the provisions. Members of one household are usually not willing to take court action against neighbors for an infraction of the agreements. An impersonal group such as a local property owners association can be very helpful in policing the development and obtaining compliance with the restrictions.

Use and Maintenance

The privilege of use as well as the responsibility for maintenance are related to ownership of land under man-made bodies of water. Prior to subdivision, all land within proposed developments usually belongs to one owner or group of owners. During the process of development, building sites are sold to numerous private individuals and some of the land usually becomes public property. Land under lakes and waterways may be included with either group -- it can become the private property of those who purchase building sites, or it can become public. If neither of these alternatives is realized, such land remains the property of the original owner.

Retention of these areas by the original owner is not advisable because this land usually has no practical usefulness or value to such persons and may become a financial burden as the result of future maintenance requirements, taxation or liability. One method of avoiding this situation is for the developer to dedicate the land under artificial bodies of water to the local government in the same manner as rights-of-way and park sites. The dedication process (44) however, involves both an offer by the owner and an acceptance by the local government. Communities usually accept dedications if such land will serve a public purpose. Not all governments, however, are willing to assume responsibility for maintenance of bodies of water, or to remove these areas from their tax digests.

Lakes and waterways may also become the private property of those who purchase building sites within the development. This can be accomplished by one of two methods. Property lines of waterfront sites may

be extended into the water in such a manner that all of the inundated land is subdivided and made a part of adjacent sites. There is some doubt as to the advisability of this method, however, as the rights and responsibilities of each owner are not well defined (42).

> . . . The courts have not agreed on whether each owner can make reasonable use of the entire lake, or whether each is confined to his own portion. The so-called common law rule permits an owner to exclude others entirely from his part of the bed and the waters over it. The civil law rule, on the other hand, permits each owner to make reasonable use of the entire lake and denies any owner the right to fill or fence or to otherwise exclude his neighbors.

This procedure also has the disadvantage of limiting ownership to those whose property is adjacent to the water -- excluding non-waterfront property owners within the development.

Another method is for the inundated land to be owned jointly by all property owners within the development. This has been accomplished by formation of property owners into a group, such as an association, club or corporation. All members of such organizations share the benefits as well as the responsibilities of property ownership. These groups may enact rules to govern the use of recreation areas and assess themselves the funds necessary for maintenance and taxes. Some local governments allow a tax reduction on land owned by such groups in recognition of the services they perform by operating and maintaining neighborhood recreation areas.

Property Owners Organizations

Successful organizations of this nature have been established in the following manner (46). The development company (initially the owner of all the property) organizes an association as part of the covenants for the development, or under articles of incorporation. Officials of the company act temporarily as directors of the organization until the new property owners elect residents of the development to succeed company officials. Administrative functions commonly performed by such groups may be classified as follows:

physical management -- maintain property, enforce covenants, approve new construction, acquire and dispose of land;

financial management -- collect and disperse funds, pay taxes and assessments, finance improvements;

social management -- supervise the operation of recreation facilities and areas.

One such organization, the Lakewood Property Owners Association, has adopted a comprehensive set of rules to govern the use of facilities owned by the group. Authority to establish and revise rules to manage the affairs of the Association is vested in a Board of Directors elected from the membership. Use of lakes and parks owned by the organization is restricted to members and their guests. Rules were adopted by the association to accomplish the following (47):

confine swimming to specified times and places, and limit boating to designated areas;

restrict the speed of watercraft, horsepower of engines, and age of operators;

prohibit the taking of glassware, pets, and alcoholic beverages into water-recreation areas;

require operators of boats to have liability insurance, and motors to have mufflers.

The association also provides trained recreation directors and lifeguards to supervise playground activities and swimming areas, and furnishes boats for use by members.

Recreation Zones

In order to promote water safety, the City of San Diego, California, prepared a plan for a body of water within its jurisdiction. The plan designated zones for various forms of water recreation. Activities such as swimming, skiing and sailing were restricted to the appropriate zones. In addition to the plan, an ordinance (48) was adopted to regulate water skiing. One of the provisions contained in the legislation is as follows:

> In prescribed areas for water skiing, all motor boats shall adhere strictly to a counter-clockwise pattern regardless of the number of boats in the area, and shall be subject to the control and supervision of the authorized representative of the City.

A similar ordinance (49) contains this provision:

> No water skier, aquaplanes or free-boarder and/or the towing craft therefor shall operate within 100 feet of another craft, paddleboard, float, swimmer, fisherman, beach, or pier structure except when taking off or landing in an area prescribed for that purpose.

These regulations also establish speed limits for watercraft, require mufflers for motors, and specify that any boat towing a skier must be occupied by two persons -- an operator and an observer.

Maintenance Districts

Local governments sometimes provide a special service (such as maintenance of lakes and waterways) which primarily benefits a select group of citizens (property owners in the vicinity of such bodies of water). In such cases special assessments (50) may be levied against these groups in order to finance the cost of providing the service. This method has often been used to provide funds for the construction and maintenance of local improvements which benefit a restricted area rather than the community in general. Such areas are referred to as improvement districts, special assessment districts, or maintenance districts.

Local governments do not have authority to levy special assessments unless specifically granted such power by the state. Procedures used to establish districts vary considerably from one place to another. In some areas property owners initiate action by requesting that the local government perform necessary maintenance. Sometimes the legislative body requires that a majority of the property owners petition for such service before a special assessment is levied. Usually, suitable notice is given and hearings are conducted to provide the opportunity for citizens within proposed districts to protest the assessment.

Summary

Both private and public forms of control are available to abate

situations such as those discussed in Chapter I. Public regulations are vital during the development stage in order to promote good design and adequate standards. Public control of land development is usually accomplished at the local level of government, within the authority granted by the state. Creation of artificial bodies of water, however, may have far reaching consequences which require federal and state approval. Regulation of the design and development of land areas and water areas is being accomplished primarily through the use of plats, permits and official maps. Protective covenants, which run with the land, can be designed to maintain continued high standards in the development of property.

The use and maintenance of lakes and waterways may also relate to the health, safety and welfare of the community. Public controls are being used to designate areas for various forms of water recreation and to regulate such activities. Special assessments may be levied against property in the vicinity of bodies of water in order to provide necessary maintenance. Private regulation of man-made bodies of water is being accomplished in some developments by contractual agreements and through organizations of property owners. Groups of property owners may be organized to own and maintain land, to regulate its use, and to provide facilities and services for its members.

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

Artificial bodies of water may serve useful purposes within residential developments. Creation of lakes and waterways often permits the development of land that is unsuitable for use in its natural state -- as poorly drained areas. These areas, which have usually been by-passed by urban growth, may be very desirable for residential development because of their location and because of the opportunity to include a special attraction such as a waterfront. Water can increase the livability of a development by providing amenities and areas for recreation.

Numerous problems, however, are associated with the impoundment of water in residential areas. Some of these are related to substances in the water such as silt and sediment, salt, chemicals and disease organisms, vegetation and debris. Other important considerations include safety, circulation, access, fluctuation of water levels and erosion of land.

Those problems, which are reasonably related to the health, safety or welfare of the community, may be matters for public regulation. Authority to abate such situations can be given local governments by states. Creation of man-made lakes and waterways is being controlled in some communities by enactment of legislation which establishes standards and requirements for their design and development. Provisions in the

legislation are enforced by use of the following:

plats -- to provide the opportunity for review and approval of proposed developments;

official maps -- to delineate special areas in which certain regulations apply; and

permits -- to grant approval for construction of dams and water control structures, for excavation, or for the impoundment of water.

Standards for physical development might include the following:

shape of water-bodies -- length, width, depth, size and proportion;

relationship to land -- height of land above water, slope of land adjacent to and under water, distance between roadways and water;

circulation -- distances between pedestrian and vehicle crossings, clearances for watercraft, distance facilities permitted to extend into water; connection of waterways with existing or proposed drainage facilities; and

maintenance -- specifications for access.

The following requirements might also be a necessary part of development:

special studies -- engineering studies to determine the suitability of water for swimming, the ability of soil to resist erosion, the potential for salt-water to intrude and for water levels to exceed desirable limits, the structural strength of proposed dams and similar structures;

special facilities -- retaining walls, fences, guard rails and barricades, water control structures, boat lifts or other means to by-pass obstructions, and areas to provide access for maintenance.

The health, safety and welfare of the community may also relate to the use and maintenance of lakes and waterways. Bodies of water may become unsuitable for swimming due to the entrance of harmful substances into the water. For this reason, communities should establish safe standards for water in swimming areas, as well as procedures for periodic inspections. The operation of power boats in some areas may cause erosion of adjacent land, produce undesirable noise, lower the quality of water, and endanger life. Public regulations to control these situations might restrict boating to specified areas, limit the horsepower of motors and speed of watercraft, require motors to have mufflers, and marine toilets to have treatment equipment. Private agreements can provide even broader restrictions than public controls.

Property owners organizations may be particularly helpful in maintaining good standards after lakes and waterways are developed. These groups, which have a direct interest in the ownership of property, often provide effective supervision of the use and maintenance of such areas.

Privately-owned land offered to a community becomes public property when officially accepted by the local government. Ownership includes not only the right of use, but responsibility for maintenance. Land which is offered to communities should be carefully appraised to determine its potential usefulness to the public as well as estimated maintenance costs. If such areas have recreational value, the dedication should include adequate access to permit use by the public. Officials of St. Petersburg, Florida, usually require dedication of lakes to the city as such areas serve as storm-water storage reservoirs for the com-

munity. In Dade County, Florida, waterways may be accepted because they are often an important means of draining large areas of the county. If areas within a development are not accepted by the local government, ownership of such areas should be clearly established.

Where man-made lakes and waterways are a necessary part of the community water-control program, space requirements for impoundment areas should be established prior to subdivision and development of land. If it is desirable to identify specific sites required for such uses, official maps should be adopted to reserve the necessary land. Preparation of an official map indicating proposed roadways may also be used to prevent the inundation of land required for public thoroughfares.

Summary of conclusions.--The following were concluded after analysis of advantages and disadvantages associated with this type of development, and review of existing controls and regulations.

1. Man-made lakes and waterways can serve desirable and useful purposes within residential developments.

2. Impoundment of water in residential areas requires consideration of many problems which can affect the health, safety, convenience and welfare of residents and others.

3. Methods are available to regulate the design, development, use and maintenance of artificial bodies of water.

Summary of recommendations.--On the basis of these conclusions and information obtained from field observations, personal interviews, correspondence and pertinent literature, it is recommended that communities should:

1. Establish suitable requirements and standards for the

development of man-made lakes and waterways within their jurisdiction.

2. Establish control over the creation of lakes and waterways in order to enforce such standards and requirements.

3. Establish and enforce necessary standards and requirements for the use and maintenance of lakes and waterways.

4. Encourage the adoption of private controls to maintain high standards for lakes and waterways.

5. Establish policies for acceptance of lakes and waterways offered to the community.

6. Determine local requirements for lakes and waterways and adopt official maps to reserve necessary sites.

Man-made lakes and waterways can be assets to residential developments and to communities. Developers, officials of local governments, and all others concerned with this type of development are therefore urged to make use of the information presented in this thesis in order to develop better residential areas and better communities.

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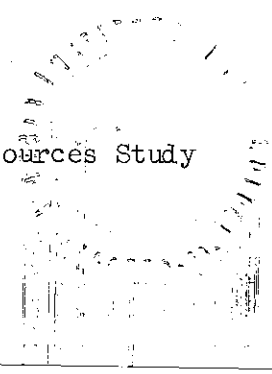

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In addition, information on the construction of lakes and ponds is published by the United States Department of Agriculture. Publications pertaining to the design and construction of dams, canals and related structures can also be obtained from the United States Department of the Interior.